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(71) Applicant: BRIDGESTONE CORPORATION
Tokyo 104-0031 (JP)

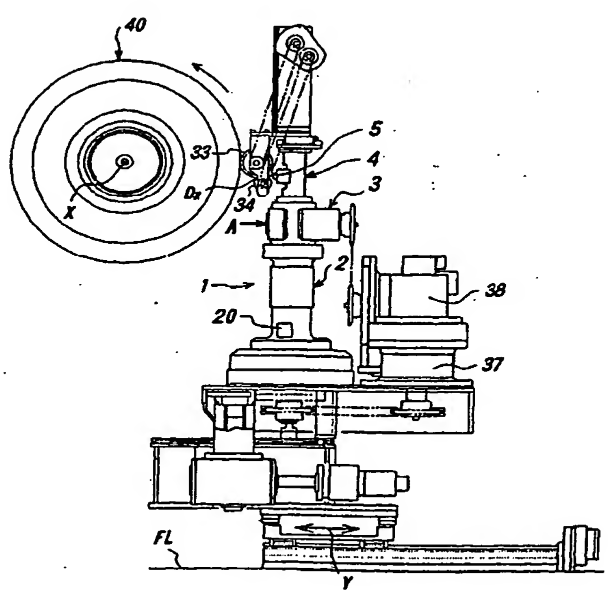
(72) Inventors:
- Ogawa, Y.,
c/o Bridgestone Corp. Technical Center
Kodaira City, Tokyo (JP)
- Iizuka, S.,
c/o Bridgestone Corp. Technical Center
Kodaira City, Tokyo (JP)

(74) Representative: Whalley, Kevin
MARKS & CLERK,
57-60 Lincoln's Inn Fields
London WC2A 3LS (GB)

(54) Method for extruding tire rubber material

(57) Tire rubber material is highly accurately and efficiently extruded by a positive displacement extruding system (1) that includes, as seen from an upstream side of the tire rubber, a screw extruder unit (2), a gear pump unit (3) and an extrusion head unit (4)with an extrusion nozzle (5), which are connected in series with each other. While the tire rubber is caused to flow through the extruding system (1), the temperature of the rubber material is measured and controlled to be within a predetermined temperature range, in accordance with the measured temperature of the rubber material. The rubber material maintained at a controlled temperature is extruded from the extrusion nozzle (5), thereby improving the positive displacement performance of the extruding system.

FIG. 1



Description

[0001] The present invention relates to a method for extruding tire rubber material to be applied onto the outer peripheral surface of a rotatable support for successively forming a green tire thereon in a highly accurate and efficient manner.

[0002] Pneumatic tires comprise reinforcing members such as rubberized cords, and various rubber members. Therefore, prior to vulcanization of tires, it is necessary to form a green tire by laying reinforcing materials such as unvulcanized rubber materials and unvulcanized rubberized cord materials.

[0003] Recently, properties required for tires tend to be highly sophisticated and more diversified, with a resultant diversification of tire-constructional members and complication of tire shaping steps. Therefore, it is difficult to completely automate the shaping step and manual works are still required in many instances, making it difficult to significantly improve the tire shaping efficiency and laying accuracy of various materials. Particularly, since the laying accuracy is highly influential over the quality of tires, it is strongly demanded to improve the laying accuracy together with the increase of the shaping efficiency.

[0004] In order to satisfy such demands, JP-B-7-94155 discloses a technology wherein an outlet orifice of a positive displacement extruder is located adjacent to a position for feeding a rubber material onto a rotatable support and the rubber material is directly extruded on the support through the outlet orifice.

[0005] With the technology disclosed in JP-B-7-94155, it is difficult to maintain the cross-sectional shape of a continuously extruded rubber material during the laying, due mainly to the so-called surging, i.e., fluctuation of the extrusion amount inherent to the extruder when the extruded rubber material has particularly a thin gauge. And also, the following problem is caused because various rubber materials are laid on the rotating support.

[0006] That is to say, since the viscoelastic characteristic differs in accordance with the kind of the rubber material, the die swell quantity tends to differ accordingly. Thus, it is required to take some measure for controlling the cross-sectional shape of the rubber material to be laid. This is attained by replacing the die with another die, or by making the die form variable. In any case, such measure for coping with the different die swell quantities requires time-consuming process, and often lowers the laying productivity.

[0007] To solve this problem, JP-A-8-21354 discloses a positive displacement pump having a rotary valve enabling to feed a highly viscous material such as tire rubber material at a constant flow rate without deteriorating the volumetric precision, and facilitating the flow of material, and proposes that the tire rubber materials discharged from the positive displacement pump is fed onto a rotatable supporter.

[0008] However, the positive displacement pump disclosed in JP-A-8-21354 has a complicated structure, and is faced with limitation of the feeding amount depending on the types of rubber materials, thereby making it difficult to achieve the desired improvement in productivity.

[0009] In order to cope with these problems, JP-A-2000-79642 discloses a positive displacement extruding system that includes, as seen from an upstream side of the tire rubber, a screw extruder unit, a gear pump unit and an extrusion head unit with an extrusion nozzle, which are connected in series with each other. A pair of rollers is arranged adjacent to the extrusion orifice and also to a rotatable support, so as to form a roller die by a gap between the rollers. The rubber material discharged from the extrusion orifice to have a gauge that exceeds the gap is passed through the roller die, so as to stabilize the cross-sectional shape of the rubber material, and is then adhered onto the rotating supporter.

[0010] The positive displacement extruding system disclosed in JP-A-2000-79642 makes it readily possible to compensate for the various die-swelling amounts that may be caused upon replacing rubber materials, to simplify the structure of the entire system, and to prevent limitations on feeding amounts of any types of rubber materials, thereby allowing to ensure a higher productivity. However, in order to enhance the flow property of the rubber material within the system, a relatively long time is often required so as to warm-up the rubber material. Moreover, when the flow property of the rubber material within the system is still insufficient, the extrusion nozzle may exhibit insufficient discharging performance for directly feeding the rubber material onto the rotatable support. It is highly desirable to eliminate these problems and improve the positive displacement extruding system disclosed in JP-A-2000-79642.

[0011] Accordingly, it is a primary object of the present invention to provide a technology that improves the positive displacement extruding system disclosed in JP-A-2000-79642, in such a manner as to achieve a sufficient flow property of the rubber material within the system and a satisfactory discharging performance of the extrusion nozzle.

[0012] According to one aspect of the present invention, there is provided a method for extruding a tire rubber material by a positive displacement extruding system that includes, as seen from an upstream side of the tire rubber, a screw extruder unit, a gear pump unit and an extrusion head unit with an extrusion nozzle, which are connected in series with each other, said method comprising the steps of: measuring the temperature of the rubber material flowing through the extruding system; and controlling the rubber material to be within a predetermined temperature, in accordance with the measured temperature of the rubber material, while the tire rubber is caused to flow through the extruding system, and maintaining the predetermined temperature of the rubber material before it is extruded from the extru-

sion nozzle.

[0013] Advantageously, the rubber material flowing through the screw extruder unit and the gear pump unit is maintained at a temperature within a range of approximately 85-95°C, and the rubber material flowing through the extrusion head unit is maintained at a temperature within a range of approximately 95-100°C.

[0014] It is preferred that the screw extruder unit of the extruding system includes a cylinder and a screw that is rotatable in the cylinder, wherein the cylinder is controlled to have a temperature that is lower than the temperature of the rubber material flowing adjacent to a downstream end of the screw.

[0015] It is preferred that at least one of the screw extruder unit, gear pump unit and extrusion head unit of the extruding system is provided with a heater that is operated in accordance with the measured temperature of the rubber material, wherein the heater is operated before the extruding system is operated, so as to preheat the rubber material within the extruding system.

[0016] It is also preferred that at least one of the screw extruder unit, gear pump unit and extrusion head unit of the extruding system is provided with a pressure sensor for measuring the pressure of the rubber material flowing through the extruding system, wherein the screw extruder unit and/or gear pump unit is operated at a speed that is controlled in accordance with the pressure of the rubber material measured by the pressure sensor.

[0017] The extruding system may be charged with a rubber material at a temperature within a range of approximately 20-30°C, or with a rubber material at a temperature within a range of approximately 60-80°C.

[0018] According to another aspect of the present invention, there is provided a positive displacement extruding system for extruding a tire rubber material, including, as seen from an upstream side of the tire rubber, a screw extruder unit, a gear pump unit and an extrusion head unit with an extrusion nozzle, which are connected in series with each other, said system comprising: at least one temperature sensor provided for at least one of said screw extruder unit, said gear pump unit and said extrusion head unit, for measuring the temperature of the rubber material flowing through the extruding system; and control means for controlling the rubber material to be within a predetermined temperature, in accordance with the measured temperature of the rubber material, while the tire rubber is caused to flow through the extruding system, and maintaining the predetermined temperature of the rubber material before it is extruded from the extrusion nozzle.

[0019] Advantageously, the control means comprises at least one heater provided for at least one of the screw extruder unit, gear pump unit and extrusion head unit, wherein said at least one heater is operable in accordance with the measured temperature of the rubber material.

[0020] It is preferred that the positive displacement extruding system according to the present invention further comprises at least one pressure sensor provided for at least one of the screw extruder unit, gear pump unit and extrusion head unit, for measuring the pressure of the rubber material flowing through the extruding system, wherein the screw extruder unit and/or gear pump unit is operable at a speed that is controlled in accordance with the pressure of the rubber material measured by the pressure sensor.

[0021] The present invention will be described below in further detail, with reference to the preferred embodiment shown in the accompanying drawings.

[0022] FIG. 1 is a side view of a positive displacement extruding apparatus for carrying out the method according to the present invention, in combination with a roller die that is arranged adjacent to a rotatable support.

[0023] FIG. 2 is a sectional view of the extruder body shown in FIG. 1, taken along a plane including the screw axis.

[0024] FIG. 3 is a rear view of a gear pump of the extruding apparatus shown in FIG. 1, as seen from the direction of arrow A.

[0025] FIGS. 4 and 5 are sectional views of the gear pump, taken along the lines IV-IV and V-V in FIG. 3, respectively.

[0026] FIG. 6 is a side view of the extrusion head of the extruding apparatus shown in FIG. 1.

[0027] Referring now to FIG. 1, there is shown an extruding system 1 for extruding an unvulcanized tire rubber material having a predetermined constant cross-section, with a predetermined constant volume. The extruding system 1 includes a screw extruder unit 2; a gear pump unit 3 coupled to the discharge end of the extruder unit 2, and an extrusion head unit 4 coupled to the discharge side of the gear pump unit 3 and including an extrusion nozzle 5. The extruding system 1 is of a positive displacement type, mainly by virtue of the gear pump unit 3. The extruding system 1 to which the present invention may be suitably applied is generally disclosed in the applicants' co-pending U.S. Patent Application No. 09/327,613, the disclosure of which is herein incorporated by reference.

[0028] As shown in FIG. 2, the screw extruder unit 2 includes a screw 10 that is rotatably supported in a cylinder 11. For measuring the temperature of the rubber material flowing through the interior of the cylinder 11, a temperature sensor 12 is provided at the downstream portion of the screw 10, which may be comprised of a thermistor. A heater 13 is arranged to surround the cylinder 11, for heating the rubber material flowing through the interior of the extruder unit 2. The heater 13 is preferably comprised of an electric hot wire.

[0029] As shown in FIGS. 3 to 5, the gear pump unit 3 includes a driving gear 14 and a driven gear 15, which are in mesh with each other and rotatable in opposite directions. For measuring the temperature of the rubber material flowing through the interior of the gear pump unit 3, a temperature sensor 16 is provided adjacent to at least one of the gears 14, 15, i.e., adjacent to the driv-

FIG. 2

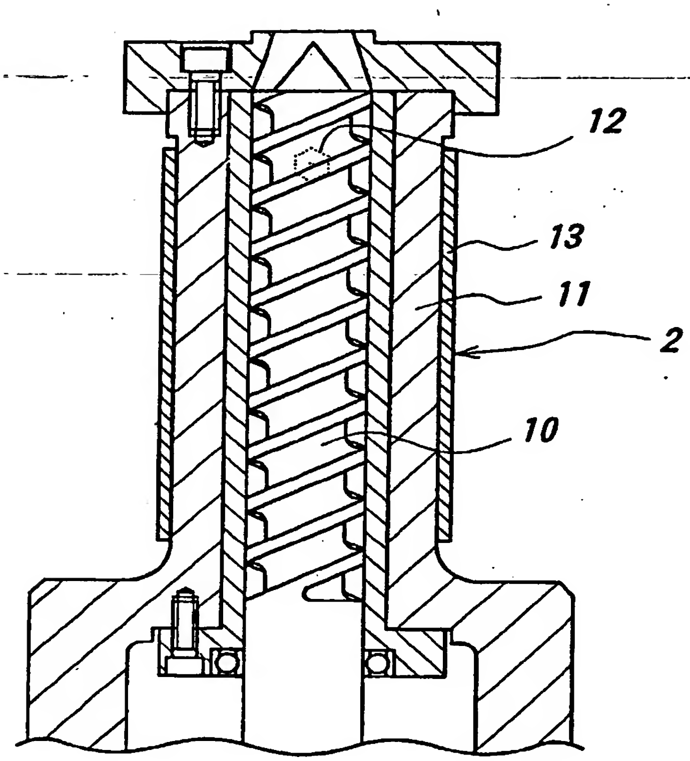


FIG. 3

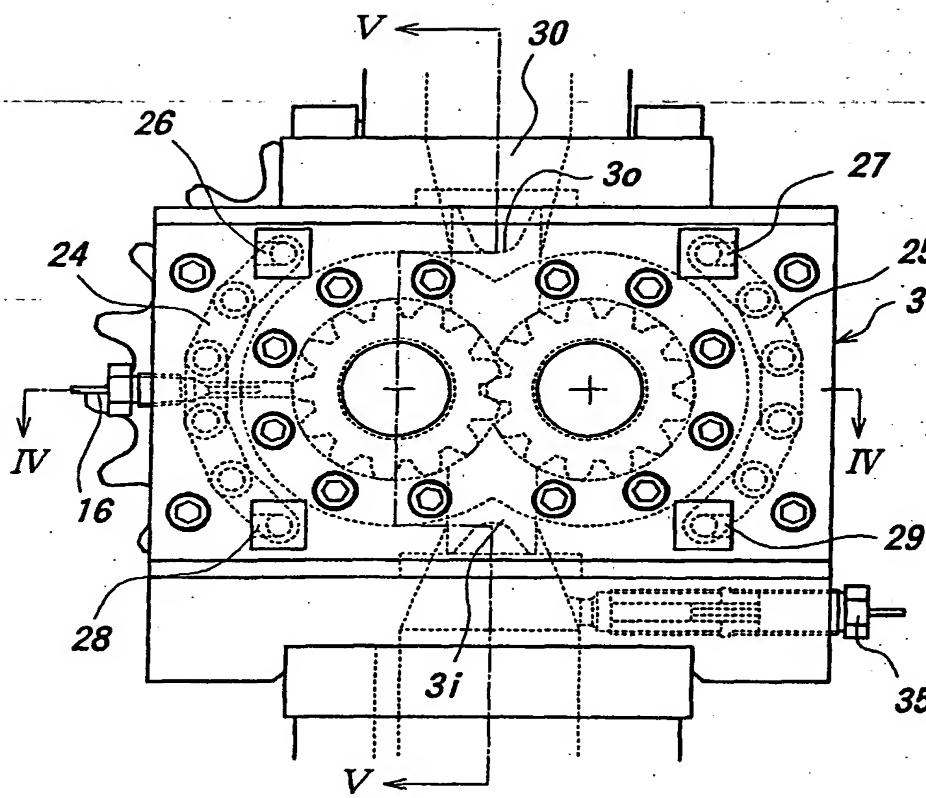


FIG. 4

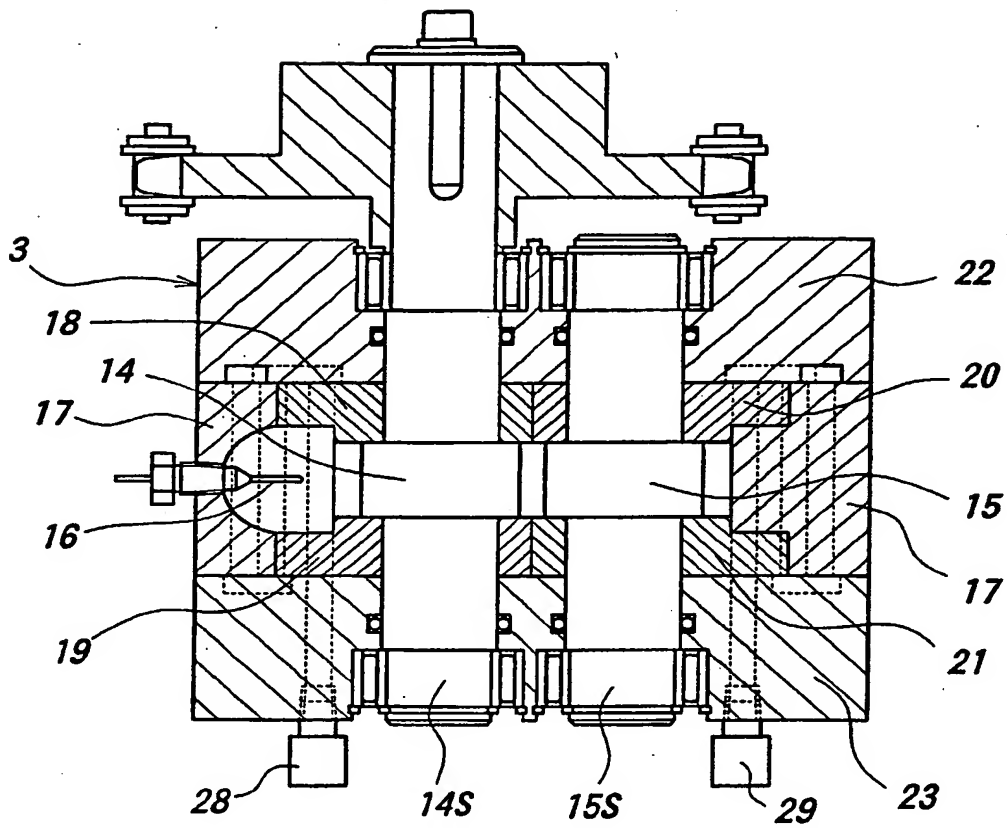


FIG. 3

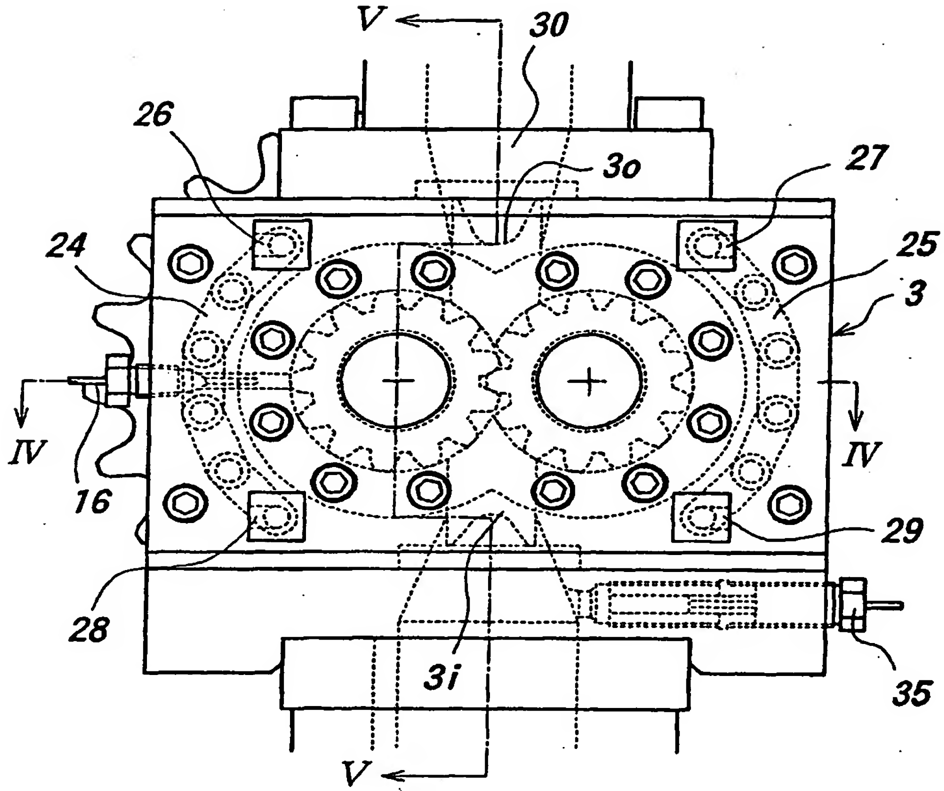


FIG. 4

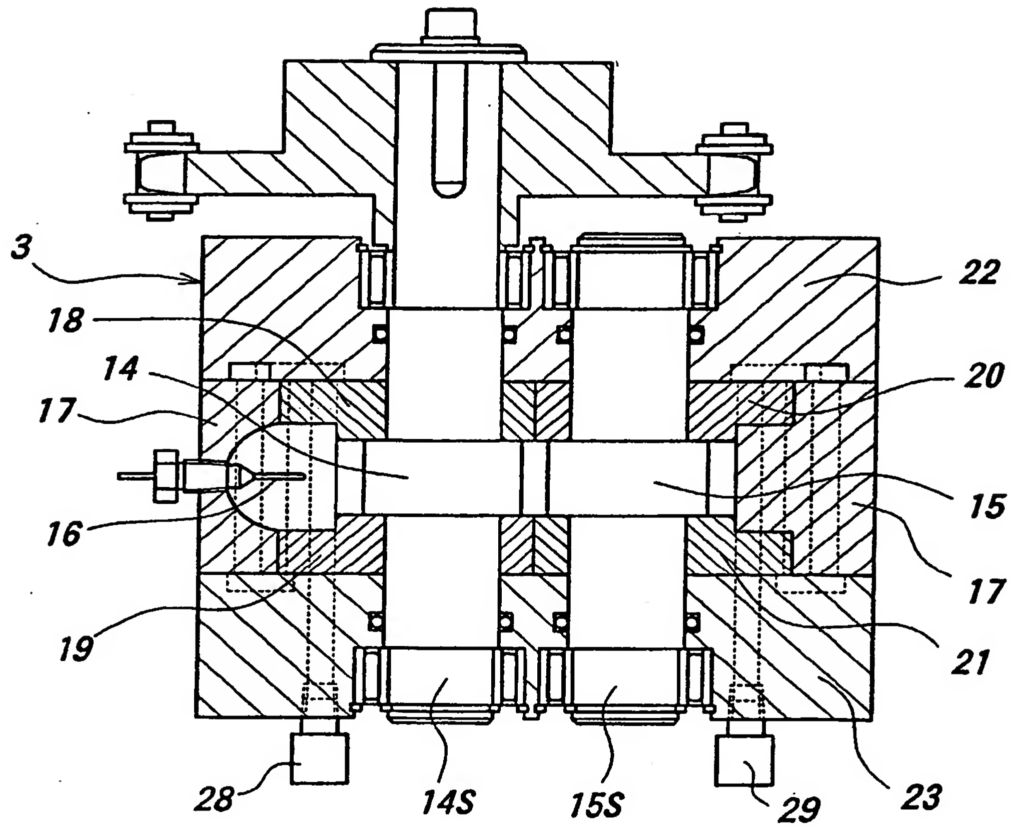


FIG. 5

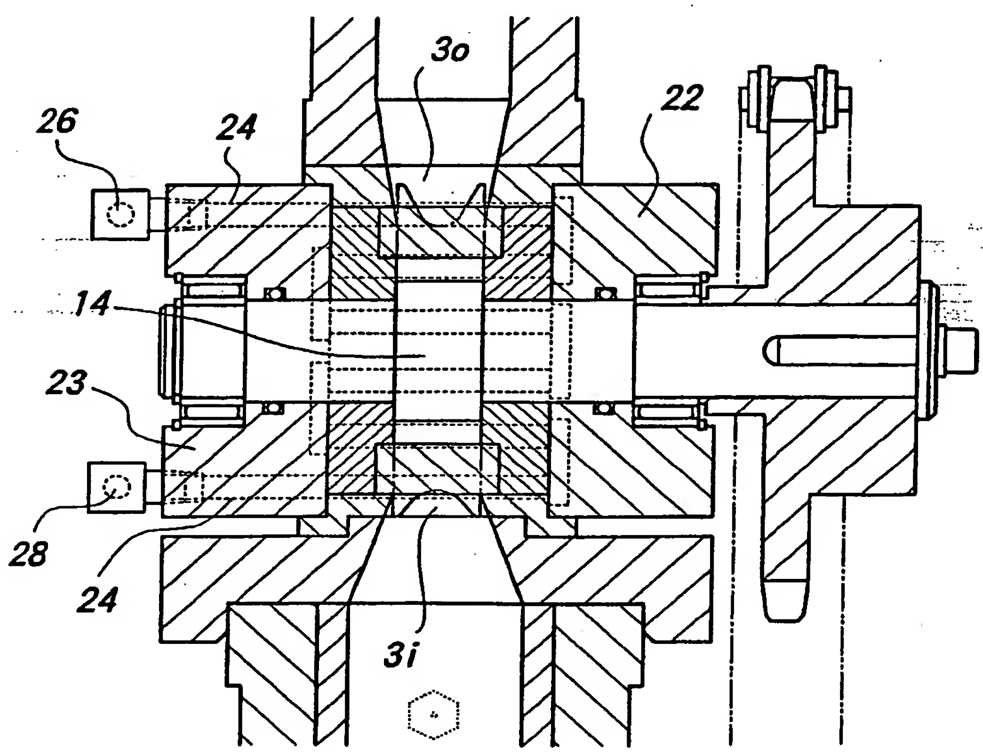
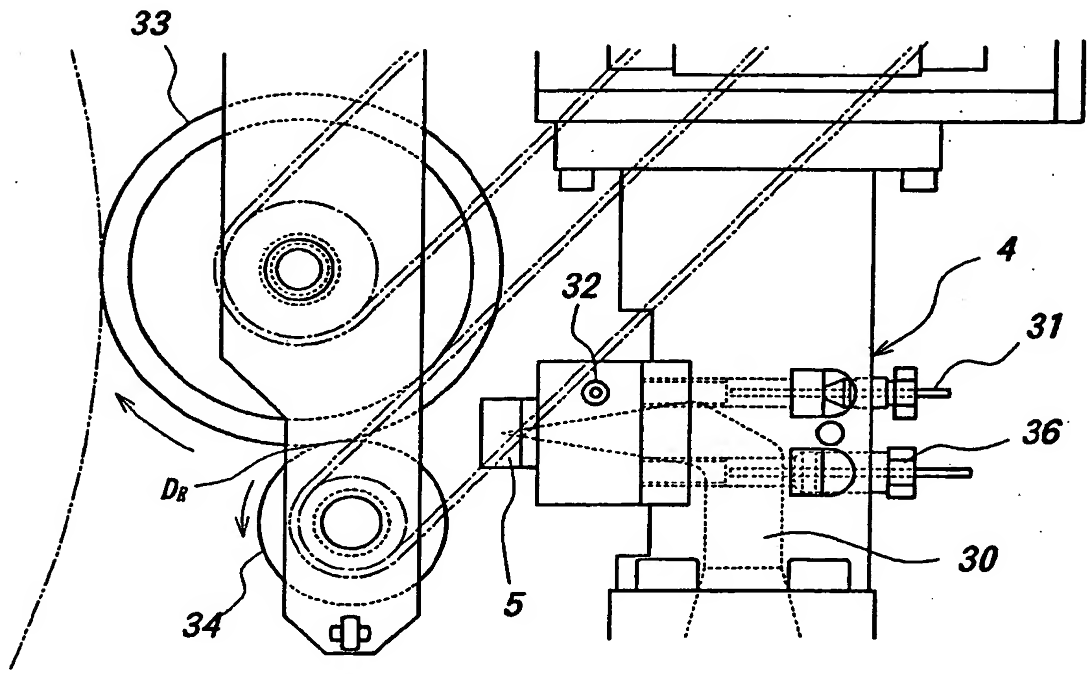


FIG. 6



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Tokyo 104-0031 (JP)

(72) Inventors:
- Ogawa, Y., c/o Bridgestone Corp. Technical Center Kodaira City, Tokyo (JP)
- Iizuka, S., c/o Bridgestone Corp. Technical Center Kodaira City, Tokyo (JP)

(74) Representative: Whalley, Kevin
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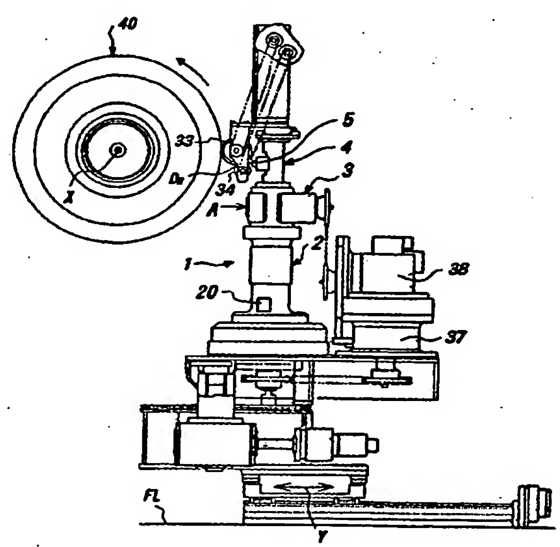
FIG. 1



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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 October 2003	Van Nieuwenhuize, O

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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